Space Weather Technical Forecast

Issued on Tuesday, 14 May 2024 at 13:20 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: A reducing risk of G1-G2 (Minor-Moderate) Geomagnetic storms days 1-2 (14-15 May). Risk of X-class flares from AR3664 decreasing from Day 3 (16 May)

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity is High with a recent X1.7 flare at 14/0209 UTC from AR3664, and numerous M-class flares. Thirteen sunspot regions are visible on the disc, with AR3664 continuing to dominate the flare risk. This remains a large and complex sunspot, however due to its position close to the west limb, this is now becoming impossible to accurately analyse with the previous assessment maintained. Significant magnetic looping remains visible in SDO imagery above the region, and indicates the potential for further significant flares and will likely continue to dominate the solar activity on the disc even as it rotates over the limb. The rest of the disc remains active with a number of smaller and simpler spots. The most complex of these is AR3670 which has developed a small delta spot in its intermediate spots in recent hours.

No Earth-directed CMEs have been observed in the past 24 hours.

Solar Wind / Geomagnetic Activity: Solar winds observed at L1/ACE started the period at strong levels, around 650km/s, with a steady decline to the current Elevated levels, near 550km/s. Density was mostly well below average due to the passage of recent CMEs. Total Interplanetary Magnetic Field (IMF), Bt, persisted at Weak levels, varying between 3-8nT, with the north-south component, Bz, mostly weakly positive (northward), but became weakly negative from around 14/1000 UTC. The resulting geomagnetic activity was Quiet to Unsettled (Kp1-3).

Energetic Particles / Solar Radiation: High energy proton flux at GOES-18 increased above the S1 threshold (10 MeV), following the various flares from AR3664, briefly reaching S2 levels on Day 1 (14 May), before decreasing back to S1 levels where it currently remains.

High energy electron flux (greater than 2MeV) observed at GOES16 was at Moderate levels, reaching 754 pfu at 13/1515 UTC. The associated 24-hour fluence was well the Active threshold but on a rising trend, with an observed fluence at 14/0000 UTC of 2.43e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Activity is expected to remain High to Moderate day 1(14 May), with further M-flares expected, and a likelihood of isolated X-flares. Probabilities decreasing from Day 3 (16 May) as AR3664 continues to rotate past the western limb.

Solar Wind / Geomagnetic Activity: There are no further CME's currently expected to arrive at Earth during the period, however due to the number of CMEs that have been released from AR3664, glancing influences from CMEs passing ahead of Earth cannot be ruled out on Days 1 and 2 (14-15 May). Otherwise, ongoing CME enhanced solar winds, along with any slight influence from CH36/+ is expected to gradually ease.

Activity is expected to be largely quiet to unsettled (Kp1-3), but due to the strength of the solar wind, coupled with any passing CME influence, there is an ongoing chance of Active-minor storm intervals (Kp4-Kp5/G1), with only a slight chance of a Moderate storm (G2/Kp6). However, this risk generally

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declines through the period with mainly Quiet to Unsettled conditions expected by Days 3 and 4 (16-17 May).

Energetic Particles / Solar Radiation: GOES-18 proton flux is currently above the S1 threshold due to the M6.6 flare at 13/0944 UTC and the X1.7 flare at 14/0209 UTC. Proton flux should gradually decline over the coming days as AR3664 rotates off the disc. However any further significant flaring from AR3664 has the potential to cause a proton response until the 16 May.

High energy electron flux is also forecast to rise as solar winds ease, with any charging that has occurred at lower orbits expanding out to GEO. This brings a likelihood of High electron flux during the forecast period, along with a chance of Active electron fluence.

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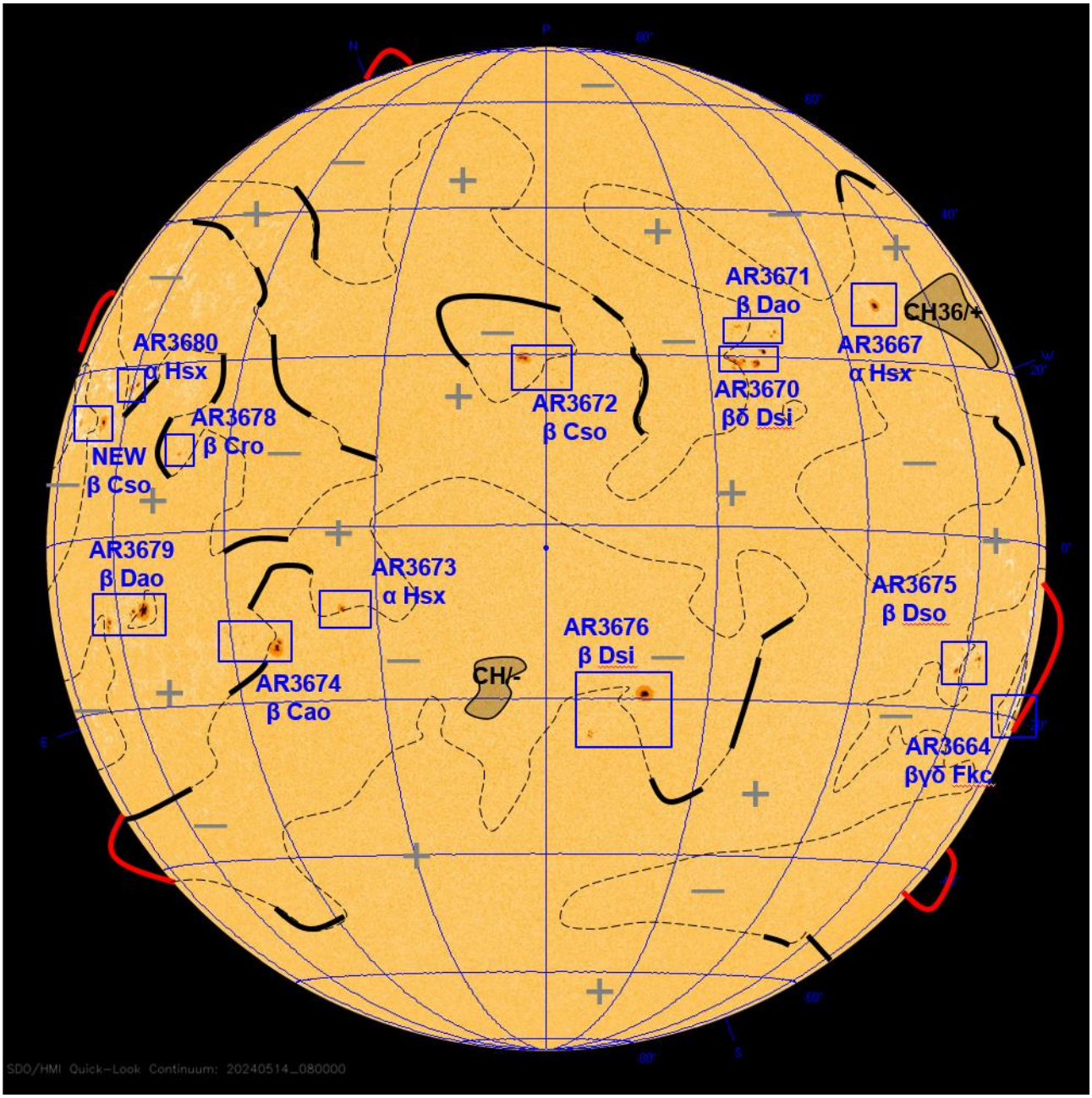
Figure 1. Solar Analysis Valid 14/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There are no further CME's currently expected to arrive at Earth during the period, however due to the number of CMEs that have been released from AR3664, glancing influences from CMEs passing ahead of Earth cannot be ruled out on days 1 and 2 (14-15 May). One being a CME from the M8.8 flare on 11 May, although this may have had a minor impact earlier today (14 May). Additionally, a second event originating from an M6.6 flare and its associated CME which occurred early on May 12 which may give us a glancing impact later Day 2 (15 May).

Otherwise the recently enhanced geo-space environment is expected to ease towards background conditions, although perhaps initially seeing the decline of wind speeds delayed due to any influence from the HSS of CH36/+, although this is likely to have a negligible effect on the geomagnetic activity.

Overall activity is expected to be largely quiet to unsettled (Kp1-3), but due to the strength of the solar wind, coupled with any passing CME influence, there is an ongoing chance of Active-minor storm intervals (Kp4-Kp5), with only a slight chance of a Moderate storm (G2/Kp5). However, this risk generally declines through the period with mainly Quiet to Unsettled conditions expected by Days 3 and 4 (16-17 May).

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	30	20	10	5
Strong	G3	No	5	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

No further Earth-directed CMEs currently expected – although the shock associated with the long-period M6.6 flare CME (13 May) could possibly glance Earth on day 2 (May 15) – low confidence.

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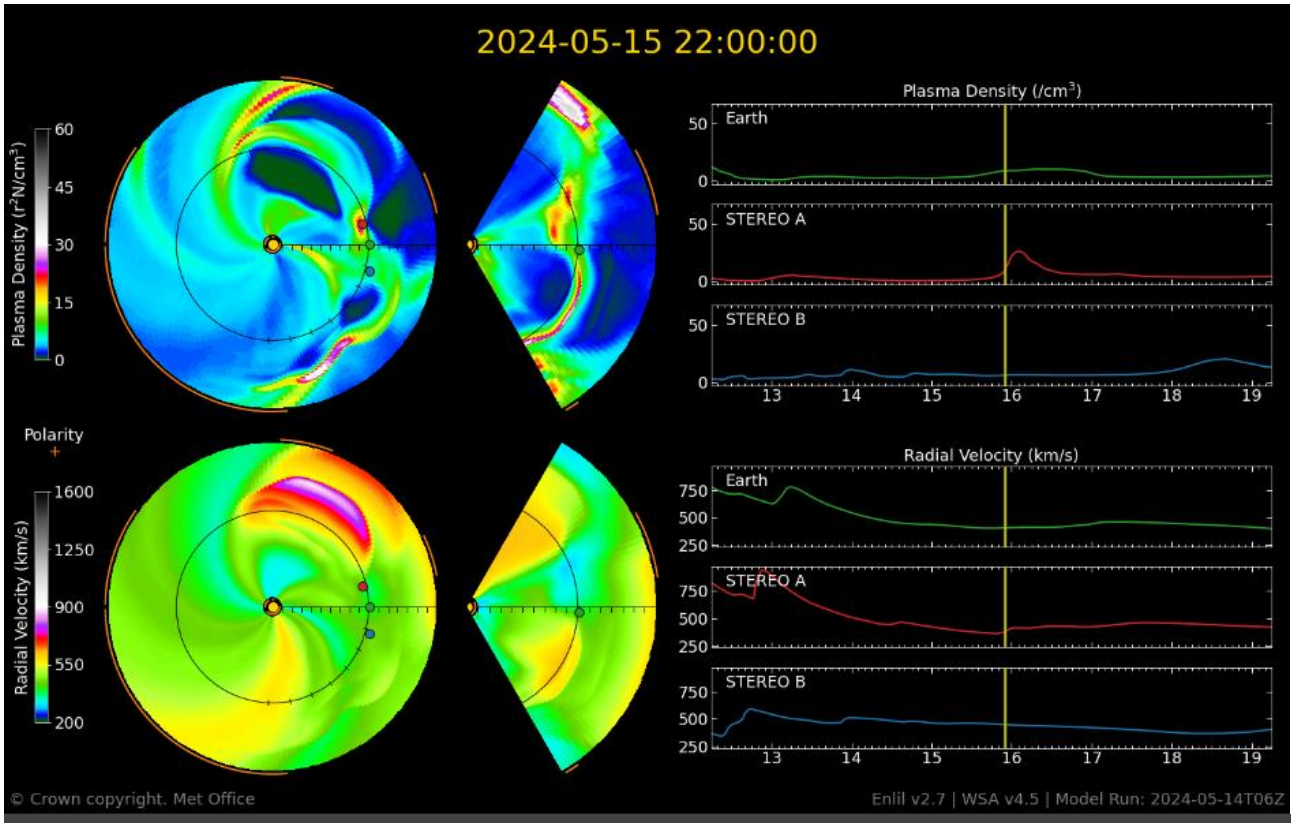
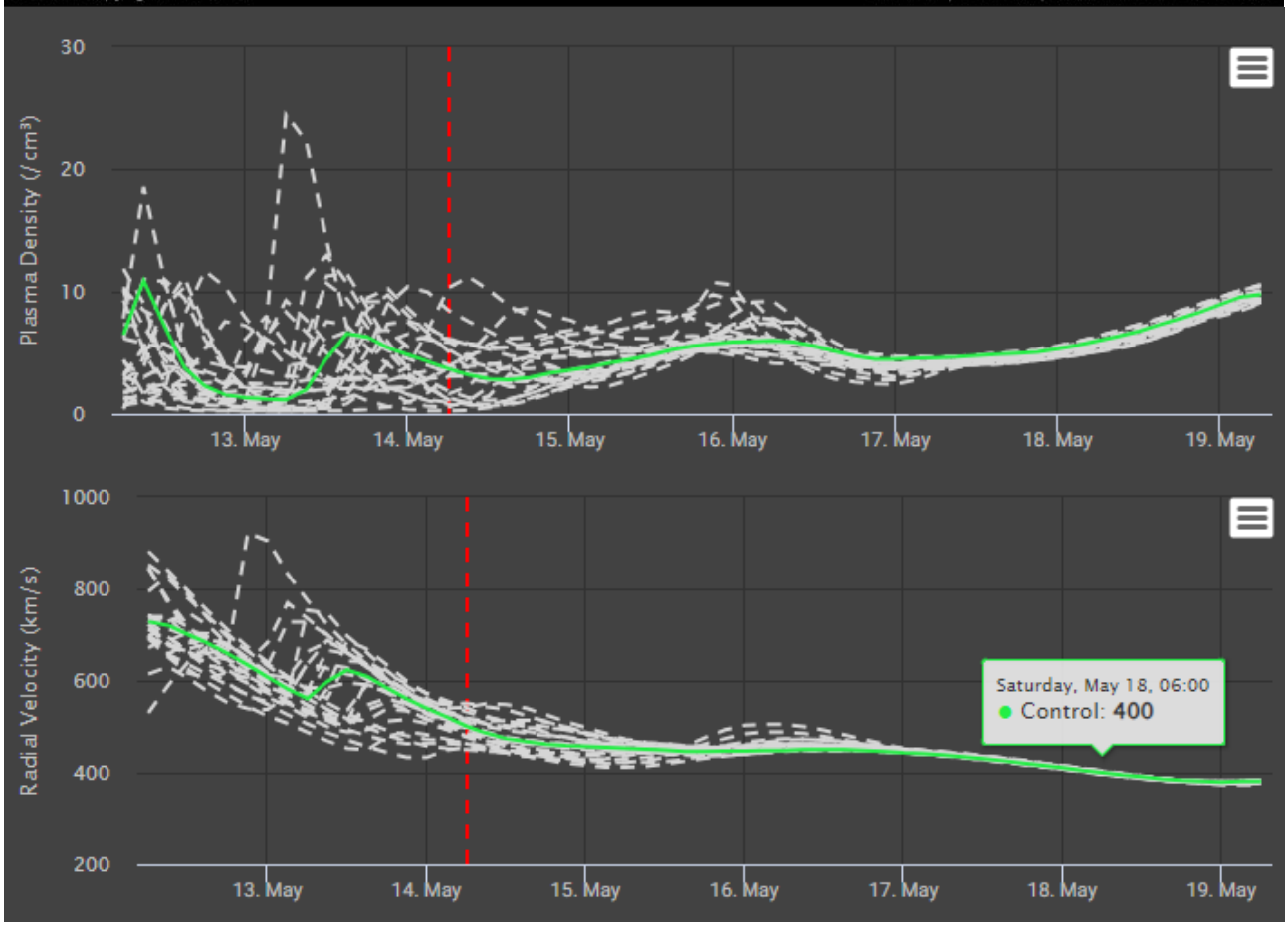
Figure 2: MOSWOC Enlil and Ensembles – note the possible glance (In ensemble) later on the 15 May – low confidence.





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Radio Blackouts - X-Ray Flares:

Activity is expected to remain High to Moderate day 1(14 May), with further M-flares expected, and a likelihood of isolated X-flares.

This risk is predominately from AR3664, now on the southwest limb. This has remained a very large and very active sunspot, with eight X-class flares and numerous M-flares observed between 08-14 May. While analysis of the region is now difficult due to the regions location, similar flares remain likely, even as this moves onto the far-side during day 1 (14 May). This is supported by the significant looping visible in SDO imagery above the spot which is showing sign of development and instability. An R4-R5 blackout (X10+ flare) cannot be completely ruled out, before the sunspot and its looping rotates far enough around the limb as to allow flare probabilities to decrease from Day 3 (16 May).

There are a total of thirteen sunspot regions on the disc, however aside from AR3664, they are much smaller and simpler providing only a chance of isolated M-flares. There is also a general slow growth trend on a number of the spots.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	90	80	40	20
Very Active	R3 to R5 X Class	Yes	70	60	20	5

Figure 3: GOES18 X-Ray flux trace.

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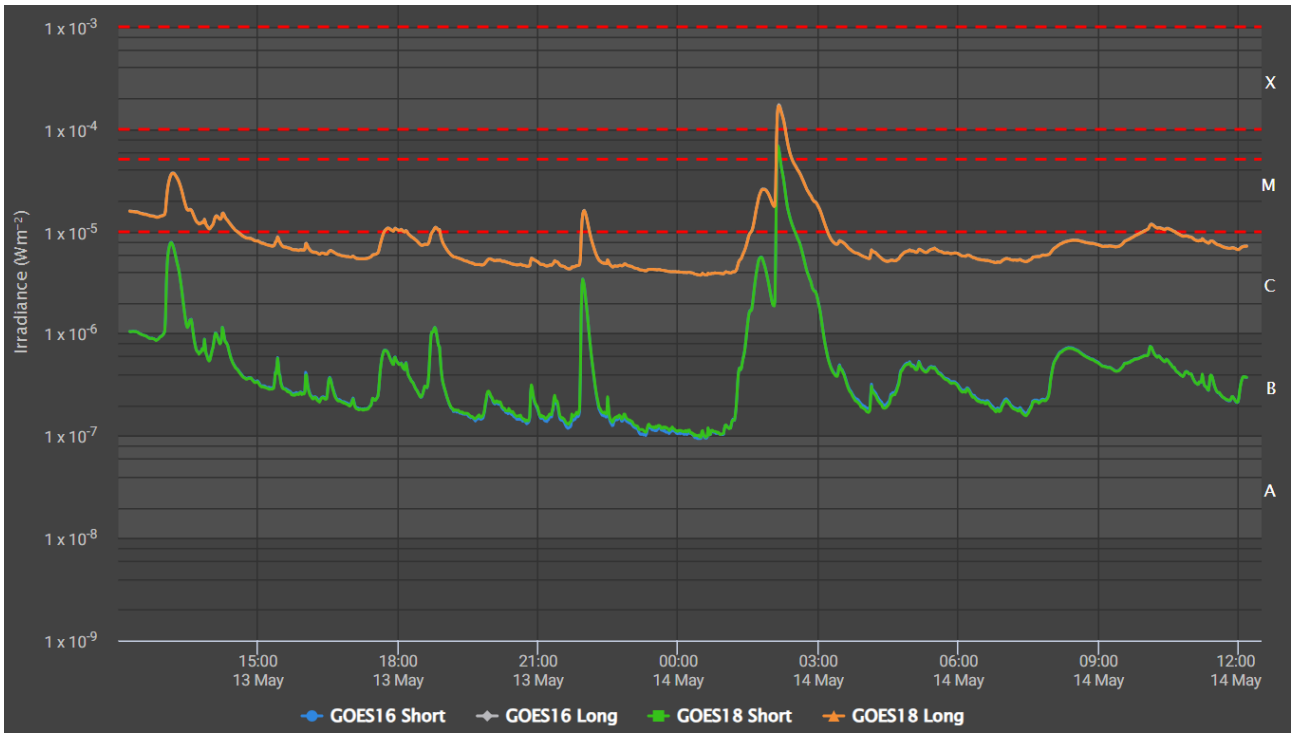

Solar Radiation Storms - (High Energy Protons):

High energy proton flux at GOES-18 increased above the S1 threshold (10 MeV), following the long-period M6.6 flare at 13/0944 UTC from AR3664 on the southwest limb. Levels increased further following the X1.7 flare at 15/0209 UTC, also from AR3664, briefly reaching S2 levels on Day 1 (14 May), before decreasing back to S1 levels where it currently remains.

AR3664 continues to be a large and potent spot, now on the southwest limb, with any subsequent flare activity having the potential to release further high energy protons that follow the Parker Spiral back to Earth until Day 3 (16 May). This will continue to bring a chance of further S1-S2 Radiation Storms, with a slight chance of reaching greater than S3 should any further X-flares occur.

If no additional flaring events occur from AR3664, proton levels are expected to gradually decrease back to background levels over the coming days.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	Yes	100	70	30	10
Very Active	**≥ S3 ***	No	10	10	10	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)

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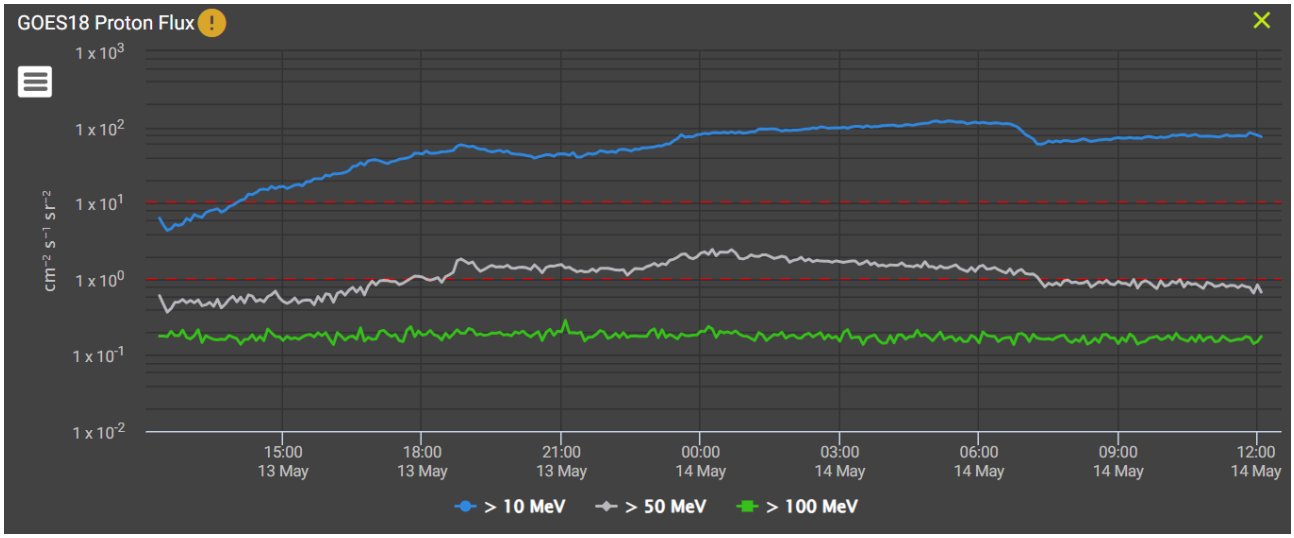
Figure 4: GOES16 Proton Flux – currently above the S1 threshold following the recent long-period M6.6 flare from AR3664.



High Energy Electrons Event (≥ 2MeV):

High energy electron flux, as observed by GOES-16 is currently at Moderate levels, but is likely to see a significant increase during the period as solar winds ease. The CME arrivals have likely resulted in a charging at lower orbits, and as the Van Allen belts ease back towards GEO, this charging is expected to bring initially more persistent Moderate flux, but likely persistently High electron flux by day 2 (15 May).

The associated 24 fluence will subsequently respond with a gradual rising trend, with a likelihood of reaching Active by the end of day 2 (15 May). This rising trend is supported by MOSWOC REFM, although the model is likely overestimating forecast values.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	40	60	70	70
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	5	10	10

Figure 5: MOSWOC REFM electron fluence.

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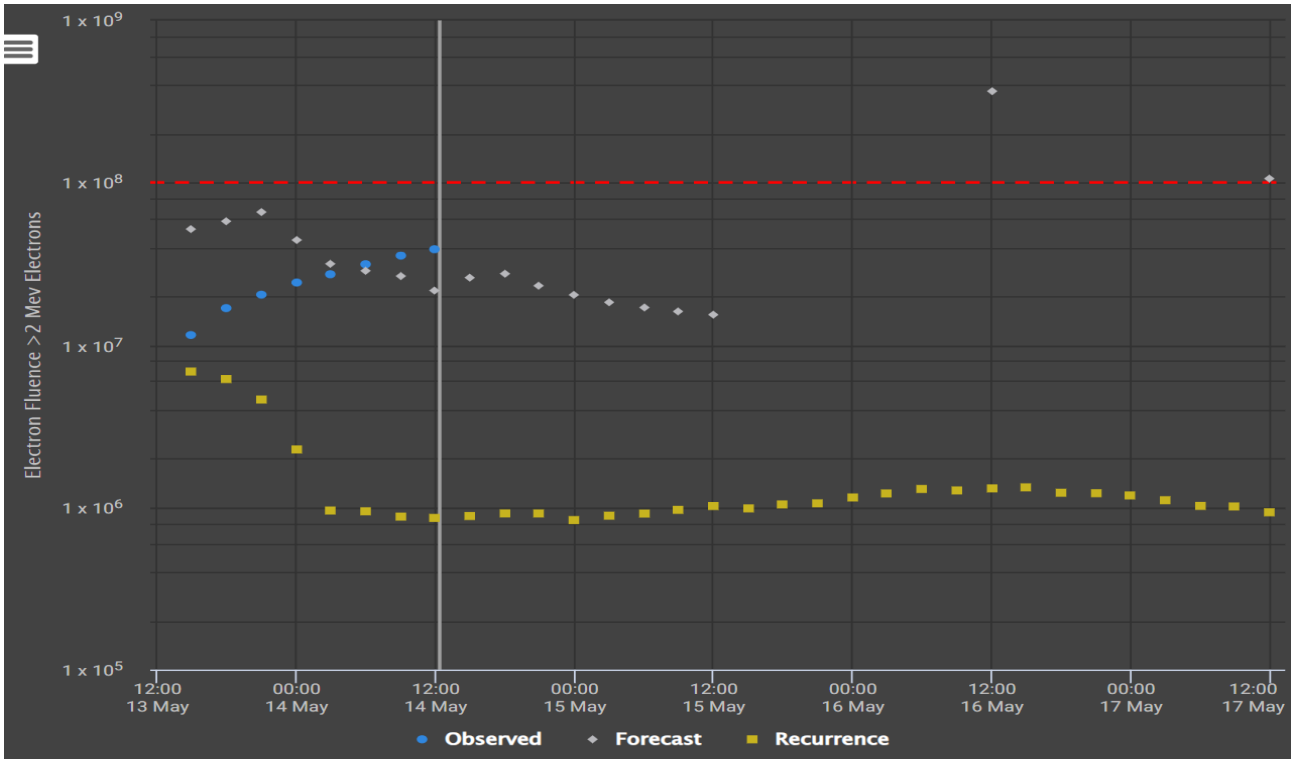

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